may, 1961

nlgi spokesman

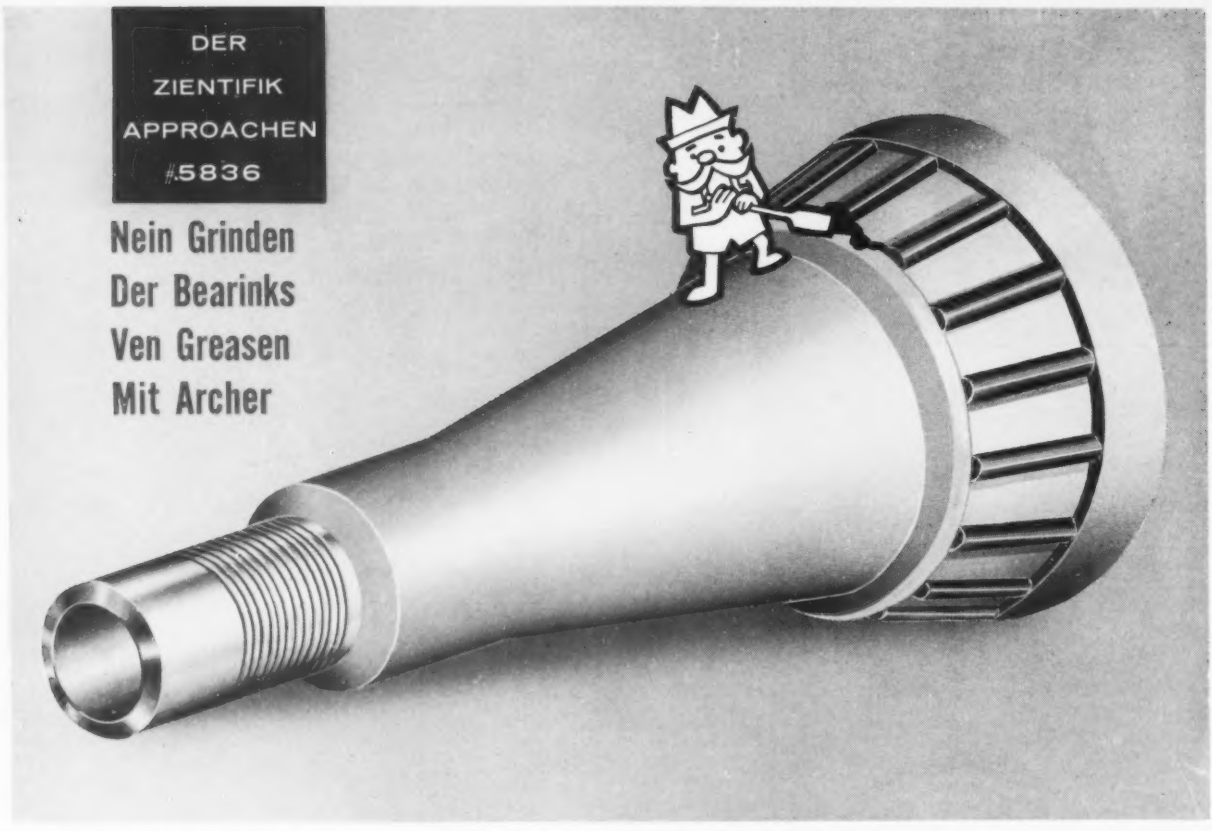
journal of the national lubricating grease institute

NON-SOAP GREASES, IV. Present Status of the Science with Special Consideration to High Temperature Applications

By J. J. CHESSICK

Costs, Credits and Collections

By M. S. MINGLEDORFF



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Volume XXV May, 1961 Number 2

Published Monthly by the National Lubricating Grease Institute, T. W. H. MILLER, Editor; VIRGINIA ALLEN, Assistant Editor, 4638 J. C. Nichols Parkway, Kansas City 12, Missouri. Telephone VAlentine 1-6771. 1 Year Subscription, $5.00. 1 Year Subscription (Foreign), $6.00.

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THE COVER

AN important part of manufacturing lubricating greases and fluid gear lubricants is seldom considered in this journal, yet attention to the "business end" of the business can often insure ever-necessary profits. Raw material costs and maintenance of proper inventories are just two of the subjects touched on in an article by M. S. Mingledorff, entitled "Costs, Credits and Collections." The lift truck shown here can speed warehousing, another part of the expenses to be computed in the cost of goods sold. For a look at internal control, turn to page 40.

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NLGI PRESIDENT'S PAGE

By F. R. HART, *President*

Lubricating Greases in the Year 2000

The article that follows is the first of four. It is based on predictions made by one of industry's foremost lubrication scientists, L. C. Brunstrum of American Oil Company. It previews the future for lubricating grease and the importance that scientists are giving this subject today, 40 years ahead of a marvelous new era. This forecast includes machine temperature ranges and the types of lubricants needed. The year 2000 is still a long way off, but time flies. Forecast No. 1 predicts the lubricating grease requirements of industrial equipment, as well as the types of lubricants needed for space engines and equipment.

Industrial Equipment

In this area, only minor technological product changes are considered. It is expected that a sharp reduction will be made in the number of greases needed; those remaining will be more broadly utilized and application methods substantially improved. For instance, more productive, newer types of industrial machines will be employed. These machines will not impose temperature ranges, water resistance or rust protection beyond that of some present-day military requirements. The demand will be for one really multipurpose grease instead of a complete line of 250 to 300 greases, as is the case today.

Very likely, future greases will be made of non-soap thickeners and special oil. If the population trend continues, fats will be needed for food. Petroleum may become more costly and synthetics more plentiful. These probabilities will just about eliminate most of the present large-volume greases. Long service requirements will demand better oxidative and physical stability.

Effect on Market

More of the newer machines will be greased "for life," or for long lubrication intervals. As the industrial pace quickens and wages go up, it will be economical to use the more expensive grease and reduce lubrication frequency. In addition, self-lubricated alloys may reduce both the volume and variety. Most of the requirements for the industrial grease of the year 2000 can probably be met by better use of the technology of today. This holds, even when atomic energy and fuel cells are considered.

Space Greases

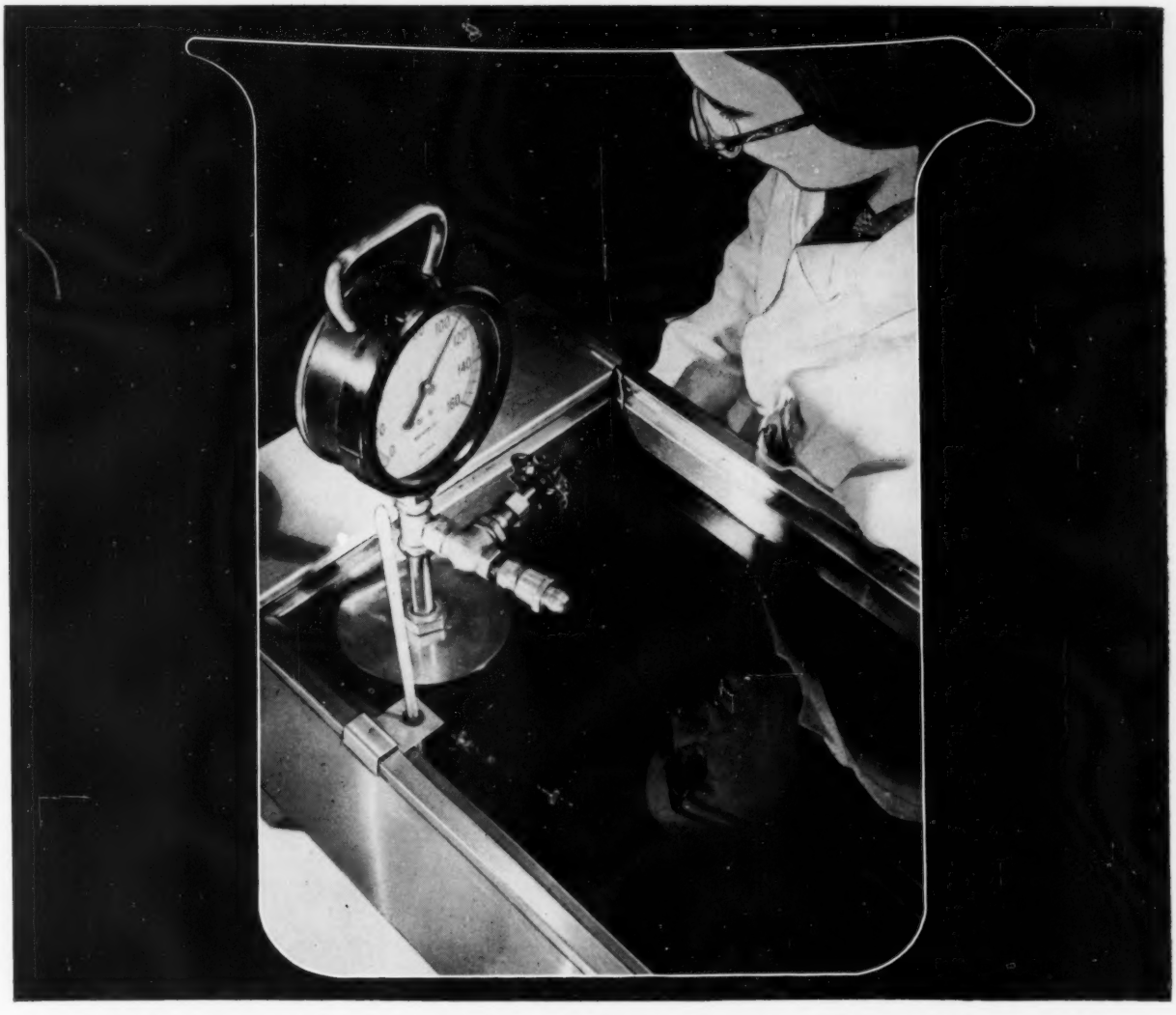
Lubrication of space vehicles and equipment will demand a great deal of technological development. There is some question if grease, as we now know it, will be the answer. Base equipment will demand lubricants of wide temperature range and very low vacuum. Already we are near the limits for two-phase systems. A grease possessing a temperature range of -100°F. to +900°F. demands a fluid lubricant with a liquid range of 1,000°F., and a compatible thickener with a solid range of at least 1,000°F. This may be impractical for anything but short terms. High vacuum causes trouble, even for solid lubricants.

Future of the Grease Industry

If these predictions are correct, the grease industry of the year 2000 will be very different, if it exists at all. This is a serious problem, because these predictions are extrapolations of existing trends, not wild guesses. If, on the one hand, we are faced with a dwindling market and perhaps nearly automatic manufacture of a very few formulae, and on the other, need for much research on space lubricants, we can pose vexing questions:

1. Will lubricating greases be as attractive to as many companies as are now engaged in grease manufacture?
2. Will the lubricating grease business shift away from the petroleum (energy) companies and toward chemical companies?
3. Will the grease business split, with a few manufacturers producing a universal industrial grease, with research and manufacture of space lubricants being handled in some special manner?

We will have to await a time with patience for answers to these questions. The forecast that will appear in the June, 1961 issue approaches lubricating grease requirements in the 21st Century from a different point of view. You will find this next forecast possibly a bit challenging. ■



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We are gratified that this painstaking process of custom grease manufacturing has created a preference for Cato greases by 2,500 Petroleum marketers.

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Oklahoma City, Oklahoma

News About NLGI

Two New Member Firms Join NLGI

R. C. Can company of St. Louis, has joined the Institute as an Associate member firm. H. H. Ellerbrock will serve as Company representative, while J. J. Galbierz will be Technical representative. The company is a manufacturer of fibre bodied cans.

Henry H. Cross company of Chicago has affiliated as an Associate member, in the category of a refiner. J. N. Waddell will serve as both Company and Technical representative to the Institute.

Technical Committee Column

CHAIRMAN L. C. BRUNSTRUM
Senior Research Associate
Research & Development Dept.
American Oil Company
P. O. Box 431
Whiting, Ind.

At this midpoint between annual meetings, it is appropriate to assess the programs of the several technical subcommittees and elicit comment or assistance from the membership.

In cooperation with ASTM Technical Committee G, the subcommittee on Manufacturing Operations has developed a full-day symposium for October. There is still room for another paper on some phase of "The Significance of Oil Viscosity in Lubricating Grease." Within the next few months, the papers will be reviewed and a few copies distributed for discussion purposes. If you desire to participate in the discussion, please contact co-chairmen R. S. Barnett or J. J. Dickason.

At the present time, the subcommittee on Consistency Projects is "hearing evidence" on the subject of extending the NLGI classification to softer grades. Of necessity, this is a slow and deliberate program; the opinion of every grease producer and consumer is earnestly solicited. Please direct your contribution to Mel Ehrlich or the chairmen of the Steering Committee.

Mr. Raisch, chairman of the subcommittee on Dispensing in Central Systems, called another session in Philadelphia in connection with the ASLE meeting. Currently, a prime objective is to consider the utility and reproducibility of the ventmeter, a rather simple device said to correlate with service. This subcommittee is interested in hearing of other experience or problems of grease dispensing in central systems.

The subcommittee on Recommended Practices was reorganized to handle several projects simultaneously under vice-chairmen. Currently the chairman, Mr. Toffoli, is himself directing the preparation of a recommendation covering the special requirements for greasing 1961 cars. Significant aid was obtained from the publications of Socony Mobil, Shell, Texaco, Chek-Chart, Alemite, Grayco and Lincoln Engineering. Proposals concerning additional recommended practices may be submitted to Mr. Toffoli or the Steering Committee.

In addition to the unheralded task of keeping the SPOKESMAN supplied with good papers, the Paper Procurement subcommittee has spearheaded a drive to have Technical Committee G minutes published in the SPOKESMAN, to establish a column dealing with short subjects of a technical nature, and assisted in the ratification of a list of letter symbols. Although technical articles for the SPOKESMAN are reviewed prior to publication, an "invitation only" situation does not prevail; if you have a paper, please offer it to Mr. Boner. He is also interested in your needs and desires in the way of technical material for the SPOKESMAN. You can also help by expressing your opinions on the G minutes and short subjects.

The small Editorial Review subcommittee does a big job of reviewing technical papers for the SPOKESMAN. It recently established the policy of "farming out" some of this work. You can help by telling George Entwistle what kind of papers you would be willing and able to review. Another service is being developed under the direction of Walter Ewbank. It will eventually take the form of a guide bulletin for prospective authors. Professor Ewbank has invited the cooperation of anyone who has experience in the field.

After two years of diligent searching, the Research and Fellow-

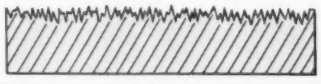
Continued on page 56

CLIMAX MOLYBDENUM

Molysulfide® News Digest

CLIMAX MOLYBDENUM COMPANY, a division of American Metal Climax, Inc., 1270 Avenue of the Americas, New York 20, N.Y.

MOLYSULFIDE INCREASES TOOL LIFE AS MUCH AS 300 PER CENT



When magnified, a piece of highly polished metal is actually smooth to touch, yet presents a cross-section of saw-tooth irregularity. Molysulfide fills in the valleys, prevents the peaks from tearing, permits plastic deformation of the metal to make a smoother surface.

COMPOUND CONTAINING MOLYSULFIDE REDUCES MACHINERY WEAR-IN TIME

During the wear-in period of machinery, permanent surface damage . . . variously described as *galling, scuffing, scoring, tearing, scratching, excessive abrasion* and *seizing* . . . is an inherent hazard.

After years of experience, leading equipment builders agree that an MoS_2 compound is the best guarantee against wear-in damage. Here are five ways such a compound, applied to moving parts prior to operation, can save you wear-in time, money and possible grief:

1. Shortens wear-in period without use of abrasives.
2. Eliminates stick-slip behavior and resists galling and seizing at bearing pressures far beyond the yield point of any metals.
3. MoS_2 particles have a tenacious adherence to bearing surfaces. Will not scrape off.
4. Need not be burnished into surface. Brush or wipe on a thin coating.
5. Inexpensive in the long run. A little goes a long way.

When writing, refer to CL-103

MoS_2 Provides Greater Resistance to Wear at High Temperatures

The Alpha-Molykote Corporation in Stamford, Conn., is now marketing a new Molysulfide bonded lubricant for ferrous surfaces.

Applied with a conventional paint spray gun, this compound fills the microscopic valleys of the surfaces of tool steel and gives on-the-spot lubrication that allows the chips to glide. Once sprayed, it dries at room temperature to a tough film that has a thickness of 0.0001—0.0008 in. and a coefficient of friction of 0.03 at 100,000 psi.

Extremely resistant to wear at high pressures and temperatures (operating temperature range -300 to 600 F) this new compound requires neither chemical nor mechanical surface pretreatment and, because of its high adherence and low friction coefficient, it increases cutting tool life as much as 300%.

Effectiveness of this lubricant comes mainly from the weak layer-to-layer bonds which allow easy sliding and, within individual layers, from the cohesive forces between Mo and S atoms that are quite strong and prevent penetration by surface asperities.

Minimum coverage coating is 285 sq. ft./lb., and consumption is about 1% of tool weight. Normal lubricating oils, cutting fluids or solvents have no effect on these coatings.

When writing, refer to CL-101

Punch Life Increased from 2,000 to 25,000 Holes in Steel Plate

These punches (11/16") were used to punch 25,000 holes in ½"—1020 cold rolled steel plate. Without a lubricant containing MoS_2, a maximum life of only 2,000 holes could be obtained.

A West Coast manufacturer was experiencing low punch life with the best available lubricants. His multiple punching operation consisted of cold shearing 50 holes simultaneously in a single steel plate. A maximum life of 2,000 holes per punch was obtained with ordinary lubricants.

Then, a compound containing Molysulfide was applied to the punch. The result: punch life was increased from 2,000 to 25,000 holes and, as can well be imagined, considerable savings were effected.

When writing, refer to CL-102

Future Meetings

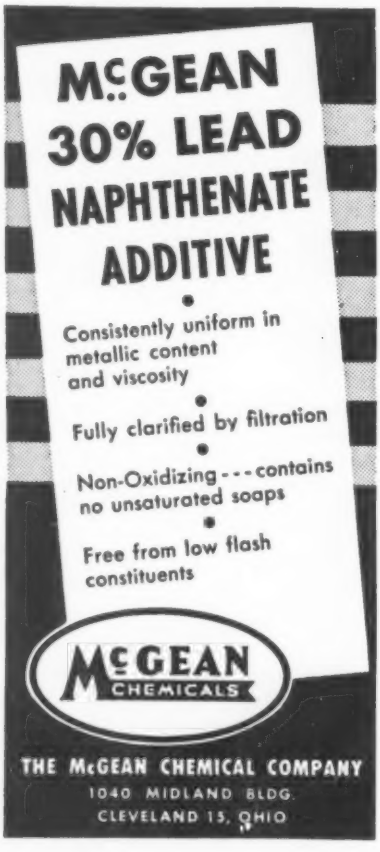
MAY, 1961

8-9 ASME Lubrication Symposium, Deauville Hotel, Miami Beach, Fla.

13 NLGI Board of Directors meeting, The Diplomat, Hollywood Beach, Fla.

15-16 Lubrication Committee of API, The Diplomat, Hollywood Beach, Fla.

16-19 API Division of Marketing, Midyear Meeting, Americana Hotel, Miami Beach.



JUNE, 1961

11-15 ASME Summer Annual Meeting, Statler Hilton Hotel, Los Angeles.

15-16 Petroleum Packaging Committee, Packaging Institute, location undecided.

24-29 ASTM Committee D-2 meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

SEPTEMBER, 1961

11 NLGI Board of Directors meeting, Roosevelt Hotel, New York City.

13 API Division of Marketing, Lubrication Committee Meeting, Traymore Hotel, Atlantic City, N. J.

13-15 National Petroleum Association, Annual Meeting, Traymore Hotel, Atlantic City.

24-26 Independent Oil Compounders Association, Annual Meeting, Villa Moderne Motor Hotel, Highland Park, Ill.

24-28 ASTM Committee D-2 meeting, Statler Hotel, Detroit.

OCTOBER, 1961

17-19 ASME-ASLE Lubrication Conference, Hotel Morrison, Chicago.

OCT. 29 - NOV. 1, 1961 NLGI Annual Meeting, Rice Hotel, Houston, Tex.

NOVEMBER, 1961

9-10 SAE National Fuels and Lubricants Meeting, headquarters undecided, Houston, Tex.

13-15 American Petroleum Institute Annual Meeting, Conrad Hilton Hotel, Chicago.

26-Dec. 1 ASME Winter Annual Meeting, Statler Hilton Hotel, New York.

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NON-SOAP GREASES, IV

Present Status of the Science with Special Consideration to High Temperature Applications

By: J. J. Chessick
Lehigh University

An original paper offered to the National Lubricating Grease Institute

I. Introduction

The increasing achievements in aircraft and missile technology must be matched by equally rapid advances in lubricant development. Rather recent demands for non-soap greases stable at working temperatures near 500°F. are being replaced by those for lubricants effective in the 1000°F. range. Obviously, better grease components must be found or developed if non-soap greases are to play an important role in critical areas of defense and industry.

The disadvantages as well as remedial measures necessary to improve the properties of thickener solids for *high temperature* applications will be considered here; not, however, without full recognition of the important and perhaps more difficult job of vehicle development. Both programs must advance together. However, there is no doubt that improvements in thickener solids are followed often by simultaneous improvement in vehicle properties.

II. Polar Solid—Nonpolar Vehicle Dispersions

Only about five or six high area, polar and nonpolar solids are available commercially for use as non-soap grease thickeners. The polar solids include the various synthetic silicas and natural occurring clay minerals such as attapulgite and bentonite. The silicas, manufactured as low bulk density materials, are readily dispersible in nonpolar vehicles. However, extreme dispersion conditions and (or) the use of organic, surface active agents are necessary for the preparation of suitable gels with attapulgite and bentonite. The disadvantages inherent in the use of polar solids in non-soap greases are many particularly when extreme, environmental changes are encountered. Certainly, none are suitable for high temperature applications. The recognition and circumvention of unfavorable properties represents the real challenge in this area of lubrication.

In order to lay the proper foundation for the recognition and correction of weaknesses in non-soap grease systems dispersions of polar solids in nonpolar vehicles

will be examined first. Polar solids such as the silicas readily form gels of desired consistency and at low solids concentration in organic vehicles of low dielectric constant. Such dispersions possess the desired low viscosity after application of a mild shearing stress as well as the ability to regain rest structure rapidly. That the thickening ability of silicas in such systems is due to water present as an impurity is well established.[1] Nor is rest structure significantly altered due to loss of water at elevated working temperatures since only trace amounts of water are necessary for gel formation. The extreme difficulties encountered in the removal of all water from such dispersions have been demonstrated.[2] Since water molecules actually join individual silica particles together the slow approach to an equilibrium junction joint energy distribution common to many gel systems is not as serious a problem here as in systems free of flocculating agents. Strong interparticle bonds are important to syneresis control, for example. Reasonably high operating temperatures—650°F. probably represents the highest investigated temperature—do not remove enough water from non-soap grease-type systems to reduce significantly rest structure in the absence of other effects.

The influence of low temperatures on grease dispersions must not be overlooked. Mobility of absorbed water molecules to junction points between solid particles which comprise the continuous phase in gels under consideration, are necessary where flocculation is brought about by trace amounts of water.[1] Flocculation of particles by larger amounts of water—monolayers but often multilayers of absorbed water—occurs through coalescence of water present on the surface of adjacent particles. Here a large decrease in interfacial free energy between *film covered* particles and the vehicle occurs associated with a large decrease in interfacial area: menesci are formed as a consequence. Both mobility and menesci formation, requirements for gel structure formation, are reduced or eliminated at low enough temperatures where the liquid-like adsorbed water film is transformed into a solid film. Little data exist concerning the transition temperature for this process in non-soap grease systems. Data have been presented,[3] however, which show that the flocculating ability of large amounts of water in glass-water, glass-toluene systems is destroyed at about –10°C. Certainly in polar solid-nonpolar vehicle systems phase transition should occur between –10° and –30°C. These systems should then suffer abnormally large consistency decreases.

Particle size and shape of thickener solids also determine such grease properties as rest structure, viscosity and even stability. Silicas are roughly spherical in shape and contribute less to viscosity increases at high shear rates than nettle-like particles of attapulgite. Attapulgite, however, should yield a more favorable junction point energy distribution[4] in grease dispersions. The use of small amounts of attapulgite with other thickeners to give a more favorable structure, reduce syneresis, etc., is a result of the strong bonds formed between nettle-like particles. A small particle size is important also to prevent abrasion by hard solids such as the silicas, but small particles offer more resistance in dispersions subjected to high rates of shear than do similar large diameter particles.[5] Obviously, the choice of a suitable thickener cannot be made without consideration of particle size, size distribution and shape, although effects of these variables in practical greases have not been assessed quantitatively.

The diameter of solid particles dispersed in nonpolar vehicles apparently determines the mechanism of adsorption of additives, impurities or wear products present or introduced into the system. Small particles behave differently than large particles. Adsorption in turn profoundly influences gel structure. The known and predicted states of solids in two component and more complex dispersions have been discussed.[6]

The polarity of the thickener solid also influences adsorption processes in non-soap grease systems. The influence of n-heptyl additives on the structure of polar solid-nonpolar grease vehicles systems was studied in this laboratory.[3] Compounds were selected as to functionality and included the amine, alcohol, acid, aldehyde and chloride. With the reminder that trace water is responsible for initial consistency, it can be stated that the alcohol and amine caused complete structural breakdown (fluidization) and at low additive concentrations. The acid and aldehyde decreased consistency somewhat but did not fluidize the gel even at high concentrations. The chloride had negligible influence. The results of this study will be reported elsewhere but it can be stated that increased surface polarity increased the effectiveness of all the n-heptyl compounds except the chloride. Factors favorable to water desorption from the junction points between silica particles determine whether a given additive can effect deflocculation. These data can explain the use of certain surfactants in grease technology to aid dispersion or to increase water resistance, for example, and may indicate the type of extreme pressure or oxidation inhibitor additives which would remain unadsorbed in certain systems. Certainly, the results are encouraging enough to show the need for further studies of interfacial changes in practical greases. These can help point out reasons for grease instability. Unfortunately, no significant programs of this nature have been reported.

The polar nature of silica or clay surfaces so important to gel formation, is itself responsible for the poor use properties of these thickeners when used in practical systems. Such polar solid-nonpolar vehicle systems are unstable in the presence of excess quantities of water at low working temperatures and lesser amounts at more elevated temperatures for example. In addition adsorption of a component added as an oxidation inhibitor, extreme pressure additive, etc., not only de-

stroys the effectiveness of the (adsorbed) additive but can also change gel structure. Solids possessing high free surface energies, possibly in the range 1000 to 4000 ergs/cm.,[2] can catalyze decomposition of organic constituents, including additives and the vehicle, itself during use at elevated temperatures. The infra-red spectrum of a silica extracted from a diester, Plexol 201 dispersion which had been heated previously to 600°F. in a Shell Roll Tester gave evidence of a chemisorbed, paraffin-type layer on the surface of the silica.[2] Structure breakdown was assumed logically, to result from surface hydrophobing due to this chemisorbed layer which prevented flocculation by water. Specific sites on the surfaces, physical and chemical heterogeneities, can be catalytically active at elevated temperatures. Specifically, acid sites on clay minerals and even silica may effect profound high temperature changes in grease vehicles due to such reactions as isomerization, cracking and polymerization. Changes in the surface and bulk stoichiometry of polar solids can also be expected during high temperature use. Indeed most polar solids become catalytically active or active in chemisorption when subjected to activation at temperatures in the vicinity of 300°C. or higher.[7] Desorption of hydroxyl water from the surface, as demonstrated many times for hydrophilic silicas, produces new groups capable of chemisorbing organic molecules possessing suitable functional groups. Attapulgite undergoes these similar reversible changes with temperatures, and irreversible changes attributable to loss of bulk water occurs on activation at 500°C. and undoubtedly lower temperatures.[8] These changes have been observed during activation of the solid alone but no doubt occur at sufficiently high temperatures in grease dispersions. Obviously these changes and others must be taken into consideration in formulating gels from polar (and nonpolar) solids particularly when these are to be used at elevated temperatures.

Surface modifications by organic molecules help to improve properties but treated solids are not suitable for high temperature applications (See Sec. III). Addition of more polar organic liquids to the vehicle can increase stability to exposure to water—glycols to silica-hydrocarbon vehicle greases, for example — but again extreme temperature applications are not possible. Surface modifications (not of the conventional type) do hold promise, but a bold, new approach is necessary.

III. Dispersions of Surface Modified Polar Solids in Non-Polar Vehicles

Desirable properties can be imparted to polar solids by use of certain organic molecules applied to their surfaces before or during dispersion. The oleophilic bentones are well known as well as the application of complex, commercial amines to aid dispersion and decrease water sensitivity of attapulgite clay. Similar amines are used to impart a degree of water stability to greases formulated with polar silicas. Estersil (now unavailable commercially) represents a silica modified by a hydrophobic surface layer of (close-packed) chemisorbed alcohol molecules. Greases suitable for many commercial applications can and are being manufactured with some of these solids. Nevertheless, their use is restricted to low temperature applications because of the instability of the adsorbed organic surfactants. Certainly, no solids treated in such fashion could be considered, even remotely, for use at 1000°F., for example. Surface modifications of the polar silicas and clays do hold promise nevertheless, but they must be radically different than the use of organic surfactants. Such treatments will be discussed in the last section.

A mechanism of thickening by Estersil and the influence of additives on the consistencies of Estersil dispersions have been discussed elsewhere.[2]

IV. Nonpolar (Hydrophobic) Grease Thickeners

The carbon blacks, graphites, Estersil and high area molybdenum disulfide represent the nonpolar inorganic solids currently available for study or use as non-soap grease thickeners. The carbon blacks, readily and rather cheaply available in a wide variety of particle diameter, surface polarity, bulk density, etc., would, off hand, appear ideally suited for use as non-soap grease thickeners at elevated temperatures. Blacks differ widely in surface polarity as a result of the variable number of oxygen or more complex molecular entities on their surfaces. Preparative conditions determine the polarity of a given specimen yet even a solid with a large concentration of polar surface complexes is much less hydrophilic than the solids discussed in Section II. Since these materials are available as very high area solids, loadings comparable to those for polar silica dispersions yield gels of favorable consistency. This is because a given weight of the black yields more particles and hence more particle to particle contacts per unit volume of grease than the same weight of the lower area silicas: structure can result even without the influence of trace water. Total interface developed between the solid surface and vehicle has been related to structure formation.[9] A comparison of the thickening ability of a polar solid and two nonpolar solids is given in Table I.

The flocculation of carbon blacks in mineral oil has been adequately investigated by Voet[10] using techniques based on the electrical conductivity of blacks. He proposes that in quiescent systems containing channel blacks of small diameter (ca. 0.022μ) association of individual particles to form flocculates first occurs followed by interlinking of these still small association complexes to form the continuous solid phase typical of a gel. Flocculation is promoted by increases in temperature, but destroyed at low shear rates. Possibly a similar process occurs in gels containing polar solids, but quantitative data necessary for an intimate knowledge of how particles interact is lacking. Methods open

to Voet are not applicable to the non-conducting polar solids.

TABLE I
Comparative Thickening Ability of Solids in Paraffin Oil

Solid	Area ($m.^2/g.$)	Wt. % Solid Used	Penetration	Calculated Interface ($m.^2/100g.$ Grease)
Polar Solids				
HiSil*	135	12	158	1620
HiSil**	135	(35)	~(158)	4700
Nonpolar Solids				
Estersil	290	15	231	4350
Carbolac 2	690	10	224	6500

*Contains trace water which aids flocculation.
**Approximate concentration to form gel in the absence of water. P_2O_5 had to be added directly to the gel.

A low interfacial free energy between the oleophilic surface of most blacks and the vehicle is not the significant factor governing flocculation.[6] Puddington[11] claims, however, that the electric charge produced on the surface of blacks during relative motion of particles of high dielectric constant in a medium of low dielectric concentration can lead to deflocculation (structural breakdown of the grease). This is due to electrical repulsion which develops between adjacent particles. This effect, if operative during use, is only of a temporary nature and could easily be eliminated if it posed a serious problem in non-soap grease technology.

The data presented above are the result of only very limited studies of carbon black greases or dispersions. Indeed, a systematic study appears warranted as illustrated by the following experimental results. Greases with good thermal and mechanical stability were prepared with the Cabot black, Elf 2, in a silicone fluid.[12] Poor bearing performance was reported. The Elf blacks are low-color channel blacks which yield short, non-flowing dispersions, properties which are apparently related to the sparsity of oxygen-complexes on the surface of the solid. A logical extension of this study[9] would be to investigate non-soap grease systems containing a long-flow channel black such as Cabot Mogul. This solid forms dispersions possessing length and flow. By using solids of similar diameter, the influence of surface polarity could thereby be assessed. Indeed, one could speculate that the poor bearing performance of Elf-containing greases was related to the rheological properties of the dispersion which in turn depended on the surface properties of the thickener solid.

Molybdenum disulfide prepared in high area form has good potential for use as a grease thickener. The low polarity of this material and the fact that the solid, itself, is an excellent dry film lubricant are powerful inducements for further studies of this material for use in vehicles such as silicones. Indeed, a method of preparing high area MoS_2 has been reported recently,[13] and preliminary results with this solid used as a thickener in this laboratory are encouraging. Little need be said concerning Estersil since it is no longer available except that despite the fact that very small silica particles have been made oleophilic via formation of a monomolecular, *chemisorbed*, film the material cannot be used for high temperature applications.

Organic thickeners have excellent characteristics for use at moderate temperatures but for reasons given below cannot function at extreme temperatures. It is strange that despite the vast number of high melting organic solids and the extensive efforts expended by industry in studying these materials only a very few, such as the arylureas, have proved useful. Obviously, thermal instability limits their range of application to temperatures probably below about 600°F. These solids also are not prepared generally in high area form, thus larger solid concentrations are needed to prepare greases of the desired consistency. Indeed, many of the organic-thickened greases are more nearly suspensions than gels. In addition solution of the thickener particles in the vehicle could be significant at elevated temperatures. This and sintering would lead to particle growth and loss of structure. These and other properties limit the applicability of such solids for use at elevated temperatures or under conditions of extreme environmental changes.

V. Some Recommendations for the Improvement of Thickener Solids

The foregoing discussion should serve, at least, to pose the question—"What properties must a solid possess to function effectively as a non-soap grease thickener?" It is apparent that solids with a lower free surface energy than the available inorganics and, probably, higher than possessed by organic thickeners are required. Small particle diameter is also a necessity, if new inorganic solids are developed because of the possibility of abrasion. Greater thermal stability than possessed by organic solids is also a principal requirement. The solid should have sufficient polarity so that rest structure readily reforms under the influence of the ever present impurity, water, or strong particle-to-particle forces. Particle size distribution, particle shape and other factors must be considered also.

The most logical approach to the production of solids with lower surface polarity than silicas or the clays centers on the preparation of the lower melting, soft, inorganic solids prepared in high area form. Certainly, these have been sadly neglected and when available should have wide applicability. The melting points of the new inorganics should be perhaps 200°C. above those of the organic thickeners to insure greater thermal stability. The preparation of high area MoS_2 has already been discussed.

A second approach to the production of solids with reduced surface free energy is to ion-incorporate low melting inorganic compounds into the *surfaces* of the available silicas and clays. In this way the available and the necessary high surface area of these solids can be used to advantage. This can be important since methods to prepare high area solids are complex, a fact readily apparent when one considers the extreme scarcity of solids with particle diameters in the range 0.01 to 0.02 microns. Initial success has been achieved in this laboratory by application of this technique.

Resin treatment of polar, inorganic solids by thermally stable organic or inorganic polymeric materials also has good potential in thickener development. Ideally, a monomolecular layer which polymerizes about the particle to form a coherent sheath—much like a baseball covering without stitches—is desirable for good mechanical properties. The layer must be thin, perhaps a few Angstroms, so particle-to-particle interaction is not reduced. Some functionality provided perhaps by hydroxyls in the surface coating could promote flocculation by water and consequently reduce the amount of solid necessary to form a grease. Good success has been achieved in this laboratory through surface coating silica and other polar solids with phenol-formaldehyde type resins. Other resins may be more suitable.

More speculative would be the application of suitable inorganic resins or ion-incorporation of inorganics into organic thickeners. Ion-incorporation here could be achieved at very low temperatures. These types of treatments might increase stability of organic thickeners in the vehicles at elevated temperatures and prevent particle growth. Certainly, surface polarity could be increased thus reducing the amount of solid necessary for formulation of given grease. Unfortunately, too few or no organic solids are available with large surface areas, except, perhaps those prepared "in situ."

Definitely further investigations into the possibility of using carbon blacks and graphites in non-soap grease systems are called for. Surface modifications proposed here or others could prove useful with these solids also.

Since organic thickening agents will continue to be a major investigation effort, it is recommended that available, fundamental data concerning particle growth be utilized to define program paths and help interpret the large mass of data collected. Information concerning the desired characteristics of organic powders and means to approach these properties have been discussed,[14] for particles which grow by condensation of molecules onto very small nuclei.

Many other recommendations undoubtedly will emerge if the factors responsible for gel formation and stability are recognized. Indeed, the most fruitful approaches to grease development should come from industrial workers who possess the tremendous advantage of a vast fund of practical performance data. No such success will be achieved, however, unless they ask themselves—"What properties must the solid possess to meet the requirements?"

Acknowledgement

This article was based on work performed under Air Force Contract AF 33 (61)-7120 under the monitorship of the Materials Laboratory, Wright Air Development Division, Wright Patterson Air Force Base 1, Ohio. Grateful appreciation is extended to Messrs. Herbert Schwenker and John Christian of the Center for educating the author in the art and problems of grease technology.

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Costs, Credits and Collections

By: M. S. Mingledorff, International Lubricant Corp.

Presented at the IOCA 13th annual meeting, Highland Park, Ill., September, 1960

Introduction

The subject of this discussion is divided into three principal parts; first, a relatively short treatment of several hidden cost items which come under the category of "Cost of Goods Sold"; second, some observations concerning the topic "Credits" and third, its natural partner or follow up, "Collections."

During 1960 the expression "Profitless Prosperity" made its appearance in newspapers and in business magazines.

This is an oblique way of saying that business is good but profits are not. Most of the trouble in this situation lies in the gross profit or gross margin on sales. Expenses have gone up a little during the past year, and labor costs take a good deal of blame for the increase. It is the shrinking difference between sales and cost of sales that has been causing some concern.

Costs

Cost of Goods Sold

Of course the keen competitive situation may well have been the principal cause of a decrease in gross margin but, at the same time, it has invited our attention to the other factor involved: the cost of goods sold. It is this particular area of the profit and loss statement that might prove interesting.

In 1960 Dun and Bradstreet published the results of a survey on the operations of 135 jobbers of petroleum products (Figure 1). Perhaps some of you have seen this data. At any rate, it presents an excellent starting point for our discussion.

Note that the cost of goods sold amounted to 82½ per cent of the net sales, leaving a gross margin of only 17½, out of which expenses of 15 per cent must be paid before netting any return on investment. It is interesting, but probably not unexpected, that delivery costs head the list of expenses.

Whether these ratios will apply accurately to your particular business is not at all certain; but in any event they may possibly be used as a guide for judging the performance of some of your customers. The profit and loss form is introduced here mostly as a means of orienting ourselves as to where particular items appear.

The area that we want to talk about now includes very few details. This portion of the statement—cost of sales—is broken down further into several items as you will see in Figure 2.

AVERAGE OPERATING RESULTS
of 135 Jobbers of Petroleum Products
1958

Net Sales		100.0%
Less Cost of Goods Sold		82.5
Gross Profit or Margin		17.5
Less Expenses:		
Delivery Expense	4.0	
Owners' Compensation	3.1	
Employees' Wages	2.7	
Occupancy Expenses	1.8	
Depreciation Equipment	.9	
Maintenance Equipment	.4	
Bad Debt Losses	.2	
All Other Expenses	2.8	
Total Expenses		15.9
Net Profit Before Income Taxes		1.6

Source: Dun & Bradstreet Survey Sponsored by Cities Service Companies

FIGURE 1.

CALCULATION OF COST OF GOODS SOLD
(Expressed as a Percent of Net Sales)

Cost of Goods Sold:		
Beginning Inventory	6.0%	
Add Purchases	82.7	
Total		88.7
Less Ending Inventory		6.2
Total Cost of Goods Sold		82.5

FIGURE 2.

For the moment disregard any manufacturing or blending expenses because it is possible that some of you are not concerned with this processing cost or it may be that you do not include it as a cost of sales item. At this moment we desire to concentrate our

attention upon inventories and purchases where no costs are apparent.

The latter two items represent a variety of activities and they usually involve quite a bit of money. Figures representing purchases and inventories are the result of the physical handling of goods, and this physical movement is most difficult to trace and to control.

Raw Materials

We shall assume that purchasing is done on the most efficient basis, that discounts are taken when allowed, that the price is right consistent with quality, and that the materials get into your place of business.

The next question which arises is: "Am I getting everything that I paid for?" For example, "Am I taking as many gallons of oil or additive out of that tank car or truck as I should?" It is within the realm of possibility that a three-compartment tank car might be received fully loaded and then checked out as empty after two compartments have been pumped. The error might go undiscovered for some time. You will also be concerned with the quality of the goods received as well as the quantity, particularly if you are buying on specification. Clingage is sometimes an interesting factor. However the number of containers dumped must be quite large and the material involved, such as oils and additives, must be fairly expensive, in order to make this worthwhile.

The receiving clerk, or the man who has charge of checking in your goods, is a very important person when it comes to raw material costs. We are all apt to lose sight of the fact that material is money. It isn't cash or currency, true; but it does represent dollars that you are spending just as well as an expense or any other disbursement that shows up on the financial statement.

When material is packaged for shipment, we are faced with the question of whether the correct amount is being delivered to the customer. If tanks, kettles or other vessels are not strapped and gauged correctly, or if scales and meters are not checked regularly, you may be giving something away. Ninety-nine times out of a hundred, if you shortchange a customer you will hear from him loud and clear but, on the other hand, very few people complain about receiving too much.

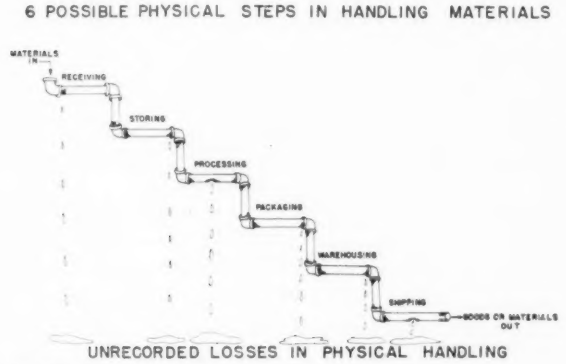

FIGURE 3.

Inventories

Inventories are important. They must be taken accurately and they must be calculated accurately; otherwise, as navigator of your business ship, you are trying to sail without your true bearings, that is to say, you will never know what your cost of goods sold really is. While it is true that what you miss on an inventory count is not an actual loss and you may pick it up on the next inventory, your comparison of two periods, whether they are months or years, is no longer valid. And neither is your comparison of performance with other firms as accurate as it should be. With the increasing number of high cost additives and chemicals necessary in the compounding of modern lubricating oils, the matter of correct inventory figures assumes greater importance.

When doubt creeps in concerning the amount of inventory, that doubt will extend to the cost of goods sold, to the gross margin, and finally to the net income on the statement of profit and loss. When uncertainty begins to enter one's mind about figures, this feeling extends to one's fellow men and you start to wonder if anyone is hauling merchandise out of the plant without benefit of an invoice. This kind of shortage is difficult to detect, too, as we once found out when we delivered some pallets of canned oil in cases with a hole in the center of the pile where a case should have been. We heard from the customer about this one!

Stock Accounting

Errors or mistakes, in the cost of goods sold section are usually detected by comparing something that actually *is*, with what it should be according to a paper calculation. For example, if 20,000 gallons of oil were purchased and 10,000 were sold, there would still remain 10,000 gallons on hand. If actual inventory indicates only 9,000 gallons are on hand, it is time to begin investigating. This is a very simple illustration of what is termed "stock accounting."

It is admitted that paper verification of a series of physical handlings is sometimes a difficult, if not impossible task, but it is heartily recommended as something to think about . . . and think hard.

Expenses

The subject of expenses, manufacturing, selling and administrative, has been omitted, but there is one consideration in this regard which should be called to your attention. Most of these costs are represented in writing by invoices and by other pieces of paper. When these bills are paid, they are usually paid by check. Many concerns have grown to the extent to where not even the treasurer, much less the boss, signs or sees all of these checks. In this situation, it could be very enlightening some day, to ask the cashier to turn

over *all* the checks to you before they are mailed. Psychologically and otherwise, there is quite some difference between seeing this cash actually flowing out as against seeing the tabulated and cumulative result classified on a P. and L. statement at the end of the month. For an occasional check-up, this can produce illuminating and sometimes surprising results.

Summary

In summarizing this short section on costs, we might say that hidden items in the cost of goods sold are the most difficult to discover and to locate. This is usually accomplished by comparing what actually is with what ought to be as per paper calculations. Other recorded costs or expenses are easier to find, usually the smaller the business firm is, the easier it is to find them.

Credits

Introduction

A discussion of the problem of extending credit begins with a statement of the objective of a good credit policy. Briefly, such a policy is a middle-of-the-road philosophy which encourages a legitimate prospect to buy on credit but at the same time seeks to avoid losses on bad debts.

Practically everyone has heard of the three C's of credit: they are character, capacity and capital. By character we mean honesty, integrity, fairness, responsibility. By capacity we mean the ability to conduct a business and make a profit out of it; and capital, of course, is the owner's investment in the business or the net worth.

The granting of credit is something which, in many instances, is a matter of individual judgment. Such judgment, however, must be based upon an intelligent appraisal of the facts and, if possible, seasoned by the wisdom of experience. Experience, in this regard, means a storehouse of knowledge containing many little things which a human mind acquires and a human brain uses almost subconsciously.

Information That a Creditor Wants

When a credit man considers extending credit to someone, he wants to know about his character, of course. This important attribute is not easily described on paper or accurately measured by standards or a common denominator. However, when either *capacity* or *capital* is considered, there are figures and written data which will express these qualities. They are revealed by an examination of the items usually found in financial statements; the balance sheet and the income statement.

Dun and Bradstreet has compiled a list of fourteen important ratios in 72 lines of business. These ratios express in percentages and in other ways the performance of an average firm. Thus they furnish definite clues to a businessman's capacity by comparing his results with a standard. For example, Dun and Bradstreet in the study of 42 wholesale gasoline, fuel oil and lubricating oil firms gives us the fourteen ratios mentioned. Let's take a look at seven of these fourteen (Figure 4) in order to get an idea of the information they offer us.

There is quite a bit of data in this exhibit, and if you are not able to digest it all at first glance, don't be discouraged. The meaning of some of the ratios could involve a lengthy discussion, but they have been ab-

SEVEN IMPORTANT DUN AND BRADSTREET RATIOS
42 GASOLINE, FUEL OIL AND LUBRICATING OIL WHOLESALERS
1958

Ratio of	*Figure Ratio*	*To Check on*
Net Profits to Net Sales	.77%	Overall Management
Net Profits to Net Worth	7.33%	Return on Investment
Fixed Assets to Net Worth	42.40%	Liquidity of Investment
Inventory to Working Capital	50.80%	How Much Tied Up in Inventory?
Current Assets to Current Debt	2.01 Times	Ability to Pay Current Bills
Net Sales to Net Worth	5.91 Times	Is Investment Producing Enough Sales?
Net Sales to Inventory	16.40 Times	Approx. Inventory Turnover (but this can vary depending on type of products handled)

Source of Ratios: Dun & Bradstreet's "14 Important Ratios"

FIGURE 4.

breviated in order to make them fit in the illustration. It is admitted that their interpretation could be vastly amplified and improved.

For example, in the last item it is acknowledged that inventory turnover is usually computed on the cost of sales, not on net sales. Turnover can vary considerably, depending on the types of products sold, that is gasoline, fuel oil, lube oil, TBA and so on. But the ratios do show us the value of financial statements for two purposes: (1) to analyze our own performance in terms of the standard of comparison and (2) to analyze the capacity and capital of an applicant for credit. They emphasize the need and the importance of getting statements from customers whenever they are available.

Sources of Credit Information

Aside from Dun and Bradstreet, where do the facts come from upon which you can base a decision to extend credit? Figure 5 will show some of the most important sources of credit information.

SOURCES OF CREDIT INFORMATION

General Mercantile Agencies
Special Mercantile Agencies
Credit Bureaus or Credit Associations
Banks
Salesmen
Special Investigators, Attorneys, Etc.
Customer's Financial Statements (From Him)
References Supplied by Applicant for Credit

FIGURE 5.

As you can see, there are two types of mercantile agencies and both of them do an excellent job. The first, of which Dun and Bradstreet is the most outstanding, of course, not only gives credit opinions but supplies information ranging over a wide field of business topics.

The special mercantile agency usually confines itself to one field such as furniture, lumber, jewelry and so on.

Credit bureaus or credit associations are more of the interchange type; that is, the movement of credit information flows from one member of the association to a central point, and then out again to another member.

Banks are rather hesitant about supplying much information, especially concerning their depositors. I can recollect the unusual instance where a country bank gave us a very favorable report on a customer in a small community. This case resulted in a bad debt loss of several thousand dollars when our customer went to jail for a federal criminal offense. We found out later that the customer was a close relative of the banker.

The salesman is an excellent source of credit information. He may be the only employee in your organization who has a personal contact with the customer. It is a well known fact in Army Intelligence circles that the best source of information upon the activity of the enemy on the immediate front is the individual soldier who singly or in patrols makes that all-important, close personal contact.

The salesman can report upon a man's habits, reputation, ability, location, and condition of his stock of merchandise, as well as who he is buying from. Close liaison between the credit man and the sales department can save the company from many bad debt losses. Not only is the salesman valuable in the instances cited but frequently he may be the first to sense a change for the worse in a customer's financial status.

Special investigators, such as attorneys, furnish just about the same information as a reporter employed by a mercantile agency. However, they are not as experienced or as well-trained in the field of business credits.

As we have seen from our previous discussion of ratios, figures and financial statements can tell us a great deal about a business firm as well as about many other things. While it is true that some statements are too brief or too condensed, the mere fact that they are presented in that way is enough to arouse suspicion and thus call for further investigation.

Insofar as references are concerned, nobody will ever give one, for credit purposes or otherwise, that isn't good. There was the case of the young man who said he was a very responsible person but didn't want to give his former employer as reference. It turned out he was *responsible*, all right. He was responsible for so many mistakes his former boss had to let him go.

Business Failures

No discussion of credit would be complete without a mention of business failures. Dun and Bradstreet has recently published an excellent booklet on this subject entitled "The Failure Record Through 1959." It is regrettable that we are not able to explore this topic in detail. However, the following two illustrations (Fig-

WHY DID 14,053 BUSINESSES FAIL IN 1959?

Underlying Causes	*Per Cent of Total*
Incompetence	44.2%
Unbalanced Experience	18.9
Lack of Managerial Experience	16.3
Lack of Experience in the Line	12.0
Neglect	3.2
Fraud	1.7
Disaster	1.3
Reason Unknown	2.4
TOTAL	100.0

Source: Dun & Bradstreet's
"The Failure Record Thru 1959"

FIGURE 6.

ures 6 and 7) will give us some good background information practically at a glance.

Why did 14,053 businesses fail in 1959? This chart gives us a pretty good idea. The first four reasons, incompetence, unbalanced experience, lack of managerial experience, and lack of experience in the line evidently resulted in inadequate sales. Or, to put it in another way, if your income is less than your outgo, then your upkeep will be your downfall. When a firm doesn't sell enough, it doesn't make enough profit to justify its economic existence, and thus passes out of the picture. The very fact that this does happen and that only the strong survive, should make the American system of free enterprise the greatest and the most vigorous that the world has ever known.

Figure 7 shows the long term trends in business failures during the past four decades.

FIGURE 7.

Note that the low point was reached in 1945 and '46 immediately after World War II. Since that date, and for the past fourteen years it has had a tendency to climb upward at a rather steady rate. As this line goes up, the work of the credit manager becomes more difficult and more important. It means, of course, that the extension of credit must be watched more carefully, if we wish to avoid heavy losses from bad debts.

The Credit Manager

Before we leave the topic of credit, we should consider for a moment the qualifications you might want to see in a good credit manager. His principal function, of course, is to incur a minimum amount of losses with a maximum amount of sales. This sounds like the efficiency expert who could kill two birds with one stone —and then get the stone back! The credit manager should be willing to take a fair business risk so that his company can make a reasonable profit. He should be thorough and somewhat conservative, although not too much, as we have pointed out. It would help if his temperament were even; he should be able to adopt a firm attitude and should be able to use foresight. Above all, he must have the welfare of his company sincerely and truly at heart. It can be said without fear of contradiction that a good credit man can more than pay his own way by the avoidance of bad risks and by the prompt collection of receivables.

Collections

Introduction

The subject of collections goes with the subject of credits. A firm that has a good policy on credits also has a good one on collections. A capable credit man not only collects, he also speeds up collections. In doing this he accomplishes two important things: (1) he spots a bad account in its early stages when it may still be possible to avoid a bad debt loss and (2) he provides the company with working capital it can always use. We should not lose sight of the fact that debtors can and do find out when a firm is lenient on collections. They ride that outfit and take advantage of long delays in paying their bills.

Follow-up Methods

The methods of follow-up are almost too well-known to mention. However, to review them and to refresh our memories, let's take a look at Figure 8.

COLLECTION METHODS OR STEPS

1. Statement of Account with Request for Remittance
2. Phone Calls (mostly local; sometimes long distance)
3. Personal Calls (sometimes by salesmen)
4. Collection Letters (including Specials and Registered)
5. Telegrams
6. Collection by Draft (on debtor)
7. Collection Agencies and/or Attorney (which lead to
8. Suit

FIGURE 8.

As you can see, we have at least eight collection methods or steps. It is quite the accepted practice to prod an overdue account with a sticker or a stamp or even a penciled notation on a statement of account. It is routine enough to call the attention of the debtor to his delinquency without hurting his feelings . . . and in a good many instances it works.

When a credit man makes phone calls, he talks to some of the most "promising" people in the world. The advantage of a telephone call lies in its flexibility. The attitude of the credit manager can be changed immediately; depending upon the developments brought out during the course of his conversation with the customer.

While the use of salesmen to collect overdue accounts may be frowned upon in some quarters, par-

ticularly the sales department, it is one of the best methods that can be used without making the customer sore. Once again we see the advantage of personal contact.

Collection letters have proven very useful in obtaining results. However, it has been said of the tricky, clever letters that they make a bigger hit with the one who writes them than the one who receives them.

There is no shortage of advice and material on how to write collection letters. You can get all the free samples you want from public library books. But it would seem that the best letter of this kind is the one which is considerate and which not only collects but at the same time sells your firm to the customer. I might add: always be sincere—even when you don't mean it!

There are some extraordinary characters in this world who will not respond to collection letters because they get so interested in them that they want to read the entire series. This is rather frustrating to the sender whose only recourse is to mail them all at once.

Collecting a delinquent account by drawing a draft upon a customer through his bank is probably not a widespread custom. It is, of course, a move to embarrass the customer if he cannot meet the draft and has to admit it to his bank.

Collection agencies are not normally used except as a final step. This is frequently an attempt to salvage something out of what may have been the promise of a beautiful business relationship. Sometimes it results in a suit in a court of law and sometimes it results in a substantial collection without suit. Although resorting to legal means is an expensive method and results only in partial recovery, this is better than nothing.

The Follow-up Records

To insure prompt collection, there is nothing so important as a regular follow-up. For this purpose some concerns use only their accounts receivable ledger sheets, some use separate tickler cards, others have the duplicate invoice system and some adopt what is termed the aged analysis sheet.

The ledger sheet plan is simple in that no other record is used. One of the disadvantages is that it subordinates collections to the other functions of the ledger. Unless the bookkeeper and the credit man are one and the same person, there may be some disagreement as to who is going to use the ledger and when.

AGED ANALYSIS OF RECEIVABLES September 30 1960

CUSTOMER AND ADDRESS	CREDIT LIMIT	BALANCE	CURRENT	PAST DUE			
Acme Fuel Oil Co	$ 3000	$ 576.00	$ 576.00				
True Blue Lube Co	2,000	250.00	50.00	$ 200.00			
Charles Gas & Fuel Sta.	400	80.00				$ 40.00	40.00

When too many figures get into the last column on the right, we have the danger signals that losses on bad debts may follow.

The Collection Period

The question may arise in your mind, "How do I know whether my collections as a whole are fast or slow?" Again we can turn to Dun and Bradstreet for an answer. One of their ratios for wholesale gasoline, fuel oil and lubricating oil dealers is the collection period expressed in days. As you may suppose for this line of business, it averages about one month. Figure 10 will show you how this figure is calculated.

Here we find the annual credit sales are divided by 365 to obtain the average for one day. Some of you may take exception to the use of the figure 365.

Dividing the accounts and notes receivable by the average credit sales per day results in the average collection period, although some accountants may prefer to call this the number of days of credit sales outstanding on a certain date. Averages can be deceptive. On the other hand, there may be quite a bit of logic in using an *average* receivables figure rather than selecting the amount on a given date.

However, the standard figure is computed as the formula is stated in the illustration, and if comparisons are to be made the same formula should be used.

If you would like to compare your own experience with the standard as published by Dun and Bradstreet,

COLLECTION PERIOD IN DAYS
GASOLINE, FUEL OIL AND LUBRICATING OIL WHOLESALERS
1953-1958

Year	*Avg. Coll. Period*
1953	31 Days
1954	31
1955	35
1956	33
1957	36
1958	34

SOURCE: Dun & Bradstreet's: "14 IMPORTANT RATIOS"

FIGURE 11.

Figure 11 shows the figures for the years 1953 thru 1958.

There has been comparatively little change since 1953. This, of course, indicates that gas and oil wholesalers have been doing a good job on credits and collections. The three day increase in the period from 1953 to 1958 is not as much as one might expect upon examining the total business failures. The latter increased from 33 failures per 10,000 names in 1953 to 56 failures per 10,000 names in 1958.

Conclusion

This brings us to the end of the discussion of collections and to the summarizing conclusions upon the three topics, costs, credits, and collections. The costs that we mentioned were hidden in the cost of goods sold. They are difficult to detect, to trace and to control. To seek them out will require ingenuity, to stamp them out will require determination and action.

Credits and collections call for systems, procedures, methods, routines. A good credit and collection policy is certain to pay off if these systems are instituted and carried out.

No matter how we may attempt to marshal our facts, whether we explain our high costs and low margins as the result of inflationary tendencies, whether we say bad debt losses are due to the lack of character, capacity, or capital; and that slow collections are due to the phase of the business cycle we are in, the final responsibility lies in the hands of management.

Good management will live and prosper without ever reading a textbook or listening to a fine speech. Good management usually means work, whether it is footwork, headwork, or paperwork. American business management should mean efficient management because, without it, this free country of ours cannot survive in the economic war we are now waging with the controlled economy of the Communist states.

Perhaps we in the oil industry should be thankful for the keen competition that we always face. It is this competitive spirit wherein we find the strength of American business and America as a nation. Our independence in politics and our independence in business is truly a magnificent thing and when the accounts are all balanced and the books are all closed, we will find that freedom is our most priceless asset. ■

About the Author

M. S. Mingledorff was graduated from Tulane university with the degree of bachelor in business administration in 1927. He received a Master's degree from the Harvard business school in 1933. Mr. Mingledorff is presently treasurer of the International Lubricant Corp. A recognized authority on determining cost factors in the manufacture of lubricants, Mr. Mingledorff is a previous contributor to the Spokesman.

Literature and Patent Abstracts

Solid Lubricant

Phthalocyanines Promise Good 1000-Degree F. Lubricants

Space/Aeronautics, v. 34, pp. 161-5, Oct. 1960

Metal-free phthalocyanine, a solid organic compound, has been used successfully in a WADD-sponsored study at Battelle to lubricate rolling and sliding contact bearings in the 800 to 1300°F range.

Studies using a modified Four-Ball and a rolling disk apparatus show that metal-free phthalocyanine reduces friction to a low level and cuts wear sharply in the 800 to 1300°F range. Pretreatment of the metal surfaces led to best results. This consisted of forming a film of a metal phthalocyanine on the bearing before use.

Composition

Extreme Pressure Lithium Base Lubricating Greases

Formation of lithium base lubricating greases which maintain undiminished extreme pressure properties on long storage is described by Martinek, Brennan, and Fronczak in U. S. Patent 2,959,543, assigned to The Pure Oil Co. Essentially, this quality is obtained by forming the lithium soap thickener from a mixture of hydrogenated castor oil and sulfurized phosphorized lard oil at a temperature below the melting point of the soap.

A suitable lard oil for formation of the sulfurized phosphorized ingredient has an iodine number of 70 to 80 and a titer of 34 to 37. This is first reacted with 7.4 per cent of flowers of sulfur at 330 to 340°F until a clean copper strip immersed in the reaction mixture at 300°F for one minute or at 210°F for three minutes does not discolor beyond a grayish color. This reaction time is usually about seven hours. Next, the resulting product is phosphorized with 0.4 per cent of phosphorus sesquisulfide by reaction at 220 to 230°F for about five hours or until substantially all of the phosphorus and sulfur are chemically bound, as evidenced by passing the above copper strip corrosion test. Such a product which is used in the formulation to follow contains 7.4 per cent sulfur and 0.23 per cent of phosphorus.

A typical lubricating grease is made by mixing 4.5 parts of a bright stock extract, having a viscosity of 340 SUS at 210°F, 28.45 parts of a Mid-Continent bright stock, having a viscosity of 160 SUS at 210°F, 6.31 parts of hydrogenated castor oil, and 1.58 parts of the above

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TRADE NAME	BAKER'S CASTORWAX® HYDROGENATED CASTOR OIL	BAKER'S HYDROXYSTEARIC ACID	BAKER'S METHYL HYDROXYSTEARATE
Melting Point	86°C (187°F)	69°C (156°F)	50°C (122°F)
Acid Value	2.	178.	4.
Saponification Value	180.	188.	180.
Hydroxyl Value	160.	154.	171.
Heat Stability Loss of Acid Value (6 hrs. at 285°F)	NONE	24%	NONE
Loss of Hydroxyl Value (6 hrs. at 285°F)	NEGLIGIBLE	27%	NEGLIGIBLE

Samples and technical data on request.

THE Baker ESTABLISHED 1857 CASTOR OIL COMPANY
BAYONNE, N. J.

5855

treated lard oil. This mixture is constantly agitated and when heated to 200°F, 1.32 parts of lithium hydroxide monohydrate and one part of water are added. Following the soap formation, the mass is dehydrated at 320°F for one hour, heating is discontinued, and 28.44 parts of the bright and 28.90 parts of a neutral oil, having a viscosity of 85 SUS at 100°F, are added during cooling. When the temperature is about 240°F, 0.5 parts of tetramethyldiaminodiphenylmethane are added. Finally, the mass is milled at room temperature.

This gives a lubricating grease having a worked penetration of 354 and dropping point of 376. Both after 24 hours and three months storage, the product stands a 55 pound Timken load and 130 kg on 4-Ball Tester before welding takes place.

Alkali Fusion Products of Isophorone In Mixed-Salt Complexes

Morway and Bartlett in U. S. Patent 2,962,441, assigned to Esso Research and Engineering Co., suggest a new component for mixed-salt complexes which will thicken lubricating fluids. The product is formed by heating one to one-and-a-half mols. of sodium or potassium hydroxide and one mol. of isophorone to 450 to 700°F. The reaction is carried out in the presence of oil and, in case lubricating greases are to be manufactured, may take place in the presence of the other thickener ingredients.

For example, a lubricating grease was made from the following weight per cents: glacial acetic acid 4.0; isophorone 10.0; Hydrofol acid 51 10.0; sodium hydroxide 6.5; phenyl alpha naphthylamine 1.0; and mineral oil having a viscosity of 55 SUS at 210°F 68.5. To a fire-heated kettle, equipped with agitators, the isophorone, Hydrofol acid 51, and oil were charged and warmed to 150°F. The acetic acid was then added, followed immediately by a 40 per cent water solution of the sodium hydroxide. Heating was continued and by the time the mass had reached 400°F it was dehydrated. Heating was continued to 510°F and held at this temperature until foaming ceased, after about 30 minutes. The product was then cooled to 200°F where the phenyl alpha naphthylamine was added. After further cooling to 150°F, the mass was passed through a Gaulin homogenizer operating at 5,000 psi.

The resulting smooth lubricating grease had a free alkalinity of 0.90 per cent, dropping point of 500+°F, worked penetration of 325 changing to 310 after 100,000 strokes, 5 pound drop in oxidation bomb after 340 hours, and lubricating life of 2432 hours in a bearing operating at 250°F and 10,000 rpm.

Rust-Inhibited Lithium Base Lubricating Greases

A combination of additives which, when used in lubricating greases thickened with lithium 12-hydroxystearate, will act as rust preventives, is suggested by British Patent 849,799, issued to N. V. De Bataafsche Petroleum Maatschappij.

This consists of 0.075 to 0.25 per cent sodium nitrite, added as a 10 per cent water solution, and 0.4 to 1 per cent of an oil-soluble imidazoline. Preferred compounds are N-hydroxyethyl-2-heptadecyl or N-hydroxyethyl-2-heptadecenyl imidazolines.

For example, a lubricating grease, consisting of 8 per cent of lithium 12-hydroxystearate in mineral oil, when applied to a bearing and subjected to a glass jar corrosion test, permitted heavy corrosion. After mixing 0.5 per cent N-hydroxyethyl-2-heptadecyl imidazoline and 0.1 per cent sodium nitrite, added as a 10 per cent water solution, with the lubricant, corrosion inhibition resulted in the bearing test.

In another test, which is said to indi-

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Color Gardner 1933	9 max.
Unsaponifiable	2.5% max.
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Acid Value	197-204
% F.F.A. as Oleic Acid	99.0% min.
Iodine Value (WIJS)	60 max.

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COMPOSITION

Myristic Acid	4%
Palmitic Acid	30%
Stearic Acid	14%
Oleic Acid	45%
Linoleic Acid	6%
Linolenic Acid	1%

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cate the ability of a treated lubricant to adhere to metal under wet conditions, 90 grams of the untreated lubricating grease together with 10 grams of water were subjected to a Shell Roll Test. After 25 hours the rolled product had a micropenetration of 230 (original penetration not given). When the same lubricating grease, with the addition of 0.5 per cent of N-hydroxyethyl-2-heptadecenyl imidazoline, was mixed with the water and tested it rolled over 600 hours before reaching the same micropenetration.

Additives

Some Data on the Activity of Additives Containing the CCl_3 Group

Sanin, P. I., Shepeleva, Ye. S., and Kleymenov, B. V.
Khimiya i tekhnologiya topliv i masel, 1960, No. 8, pp 24-28

Tests were made to verify the fact that molecules containing phosphorus and the CCl_3 groups were exceptionally good friction-reducing additives under high loads. The additives were used in a lubricating grease (type not given) which had a kinematic viscosity of 20.8 cs. at 50°C. The four-ball apparatus was used in the tests.

Increasing the number of CCl_3 groups in the compounds produced striking increases in the high-load properties. In lubricants containing either tri (trichloroethyl) phosphate or tri-(trichlortert. butyl)phosphate, a load of 300 kg. produced only an 8 mm. scar.

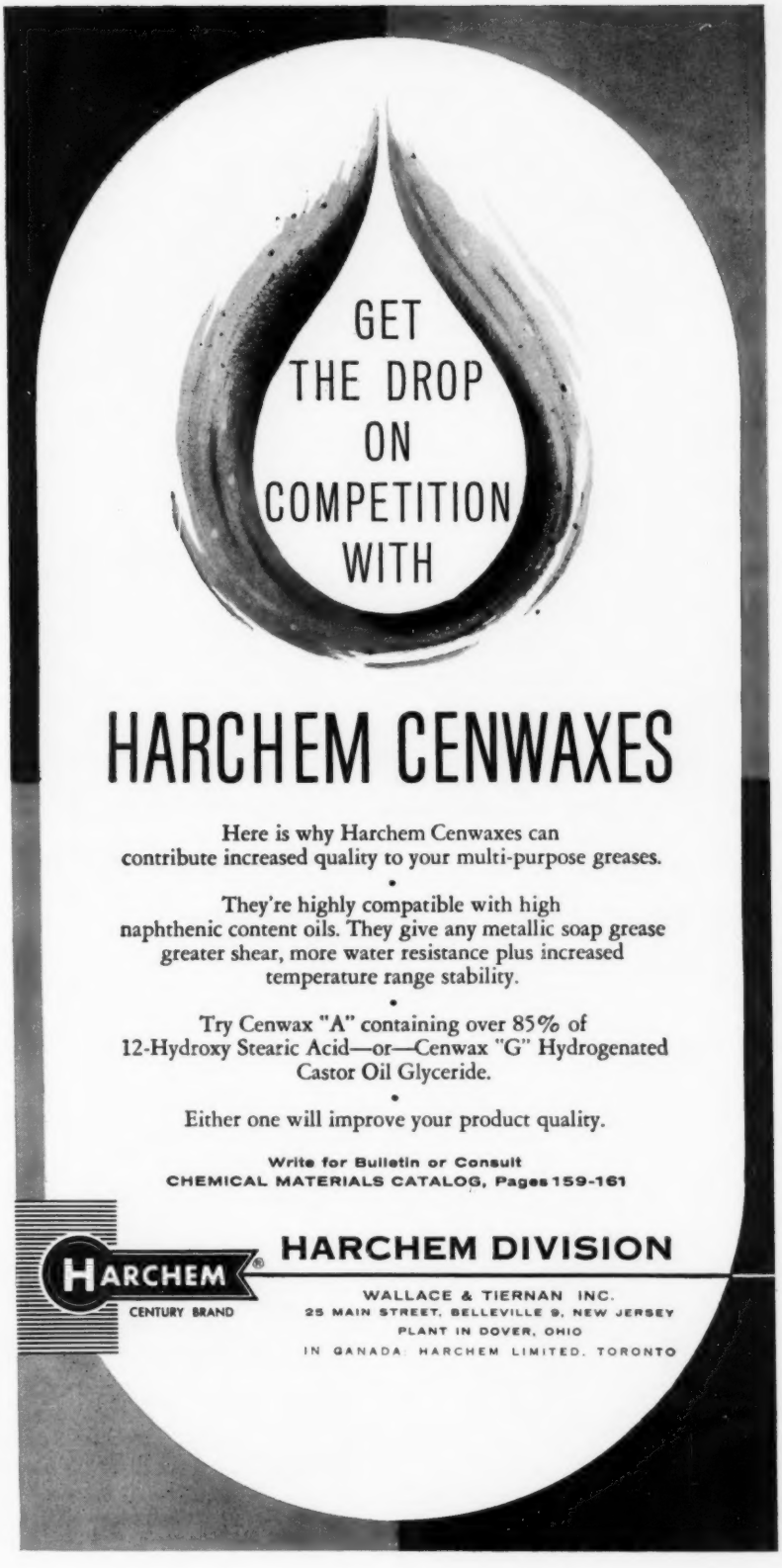
Process

Production of a Smooth Air-Free Aluminum Base Lubricating Grease

A process for producing a smooth, uniform, air-free aluminum stearate lubricating grease involves the addition of a portion of the oil to a soap concentrate under vacuum. This method is described by Richards and Thompson in U. S. Patent 2,962,440, assigned to Esso Research and Engineering Co. The procedure permits kettle finishing, but no time cycle is given.

In general, 1 to 7 parts of aluminum stearate is mixed with 25 to 75 weight per cent of the total oil and the soap is dispersed at a temperature of 250 to 450°F. Next the mass is cooled to a temperature of less than 120°F under vacuum and while stirring in the remainder of 100 parts of oil. The product is then ready to package.

For example, 30 parts by weight of a lubricating oil having a viscosity of 120 to 130 SUS at 210°F, 4.4 parts of commercial aluminum stearate, and 2.4 parts of an additive mixture consisting of 1 part of oleic acid, 0.4 part of aluminum naphthenate, and 1 part of Paratac, were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mixed in a kettle and heated to 250 to 300°F. The kettle was then closed and put under a vacuum of 6 atmospheres while cooling water was run through the kettle jacket. Then the remainder of the oil, 62.2 parts, was added through a displacement meter. When the lubricant had cooled to 120°F, it was sampled and tested for consistency. Further cooling to room temperature showed that no further change in consistency occurred. The resulting lubricating grease was almost transparent with a smooth texture.

Characteristics

Radiation Resistant Lubricating Greases

A note in *Scientific Lubrication*, v. 12, November 1960, p 27, states that Cosmos lubricating grease, manufactured by Esso Petroleum Co. Ltd., has been chosen for the critical applications of the C.E.G.B. nuclear power station being built at Trawsfynydd.

Since conventional soap-thickened lubricants broke down at levels of radiation lower than those expected in the fuel handling machine, those made with carbon black were found most suitable. When carbon black was made into a lubricating grease with a suitable mineral oil, the product was extremely resistant to radiation, was structurally stable at high temperatures, and had good anti-wear characteristics.

Tests

Dynamic Gamma Flux Grease Testing Rig

A submerged, elevated temperature, irradiation apparatus is illustrated and described in *Scientific Lubrication*, v. 12, November 1960, pp. 31-32. A motor drives a test gear set which in turn drives a shaft at 900 rpm. On the shaft are mounted four test bearings which can be loaded and also heated up to 250°C. CO_2 is circulated through the housing for the apparatus. Mobil Oil Co. Ltd. has been operating such equipment since June in the spent fuel element gamma facility at Hartell.

A Study of the Shell Four Ball Wear Test Variables. G. P. Murphy, 8 July 1960. Report No. 60-2154. Order from LC mi. $2.40, ph No. 3.30, PB 149054.

Four MIL-G-10924A "General Purpose" greases were tested under various conditions of load, time and temperature. The results were mathematically treated and the relationship between the variables and the scar diameter determined. These relationships, which hold for tests on MIL-G-10924A greases over the following variable ranges, 2 to 50 kg. load, 27 to 150°C, 10 to 180 minutes, and 600 rpm, are as follows: The scar diameter

varies directly with the 0.25 power of the load, the 0.12 power of time, and the 0.10 power of temperature. The exponential powers of load, time and temperature were also determined for mineral, diester, polyglycol, organic phosphate oils and several different lubricating grease types. The general equation for conversion of data is given. This equation is applicable only to scar diameters in the nonseizure portion of the Shell Four Ball Wear Test wear curves.

Rolling Bearing Performance Test For Lubricating Greases

Anon. *J. Inst. Petroleum* 46, pp. 328-333 (1960).

This article describes the development of a test rig, described in IP 168/59 Tentative, for determining the ability of lubricating greases to lubricate rolling bearings. The design consists of two bearing assemblies mounted on a horizontal spindle capable of being run at speeds up to 10,000 rpm. Provision is made for heating the bearings up to 150° C and to load them up to 300 lbs. radially. The test bearing is a BRM-040 single row ball bearing. This has a riveted pressed steel cage and tolerances are imposed on the initial radial float on the cage. One of the major test criteria is the ability of the lubricant to prevent wear where the balls rub on the cage pockets. Therefore, a device was perfected and is described to permit measurements of the wear.

Leakage rating	1	2	3	4
Loss in wt. of assembly in g.	Less than 1	1 to 5	5 to 10	above 10
Used Grease Rating	1	2	3	4
Softening or Hardening	unchanged	slight	uneven	much
Lubrication Ratings	1	2	3	4
	Bearing surfaces greasy or oily with even distribution.	As in 1 but grease in covers showing marked change	Lacquer or hardened grease	Bearing dry or metal particles evident
Bearing Wear Rating by feel	1 Smooth	2 Slight roughness	3 Very rough	

Cooperative tests were run with 28 grams of lubricant packed in the bearing, either without applied heat or with the temperature controlled at 60°C which is said to be representative of the bearing temperature obtained in large electric motors. A radial load of 300 pounds was applied and the test was run for 500 hours.

Experience gained during tests has led to the above ratings.

Three groups of lubricating greases were used in co-operative tests in which about three out of four laboratories rated the lubricants the same.

The first group consisted of three sodium base and three lithium base products all of which had given satisfactory service performance.

The second group contained three conventional calcium base and three general service calcium base lubricating greases, all unsuited for high temperature bearing service.

The third group consisted of six sodium base products which had given doubtful service at high speeds in bearings. Actually two of the lot gave better test results than expected.

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People in the Industry

Kerr-McGee Announces Organizational Changes

A number of organizational changes have been made by Kerr-McGee Oil Industries, Inc., and became effective in March.

H. H. Raborn, formerly treasurer and assistant secretary, has become vice-president and general manager of marketing. In his newly-created position, Raborn is responsible for the parent company's marketing, merchandising and allied functions. Continuing to head the departments now within Raborn's area of responsibility are: W. H. Doyle, vice-president, branded marketing; P. C. Bennett, general manager, property acquisition and development; L. H. Sullivan, general manager, bulk sales; A. R. Gockel, general manager, supply and distribution; D. R. Frey, general manager, product development and quality control; and W. J. Fuchs, merchandising manager.

Esso Standard Names James H. Lumpkin, Jr.

James H. Lumpkin, Jr., has been named manager of Esso Standard's Automotive division. He succeeds Robert L. Francis, who retired after 31 years' service.

Mr. Lumpkin rose through marketing posts in Esso's Virginia-West Virginia sales area and was in charge of the automotive fleet in those states from 1946 to 1955, when he moved to the New York City headquarters. He has been serving since then as assistant automotive manager.

He was born near Richmond, attended the University of Richmond and was in the Army in Europe during World War II. He was a major in Army Ordnance.

He is a director of the Private Truck Council of America, a member of the Society of Automotive Engineers, and a member of the American Petroleum Institute.

Esso Standard is a division of Humble Oil & Refining Company, principal operating affiliate of Standard Oil Company (N. J.).

Southwest Appoints Gesell As Sales Representative

John Borden, sales manager of Southwest Grease & Oil Co., Inc., recently announced the appointment of J. A. "Al" Gesell as, sales representative for the north central states area. His territory will include Minnesota, Wisconsin, Illinois and Iowa, plus parts of Nebraska, Missouri and Indiana. Mr. Borden, in his announcement, pointed out that Mr. Gesell has just completed a three month training and familiarization program at the main home office of Southwest Grease in Wichita, Kan.

"Al" Gesell graduated from Iowa university with a degree in Economics and Business Administration. Prior to joining Southwest Grease, he was employed for seven years by Anchor State Oil & Refining corporation as a district representative responsible for sales and sales promotion. His work with Anchor covered the entire field of lubricating greases and oils.

Lieut. Col. S. G. Harris Rejoins Joseph Dixon

Lieut. Col. Sidney G. Harris, who left private industry in 1951 to go on active duty with the U.S. Air Force, has retired from military service and rejoined the Joseph Dixon Crucible Co., Jersey City, N. J. He will specialize in marketing development for Dixon's colloidal graphite lubricants and coatings.

Besides Dixon, he has held exec-

utive posts with Petroleum Solvents Corp., McGraw-Hill Publishing Co. and Continental Motors. A member of the Society of Automotive Engineers, American Society of Lubrication Engineers and several military societies, Col. Harris was educated at Columbia university, University of Texas and Brooklyn Polytechnic Institute.

Manager of Economic And Marketing Research

The Esso division of Humble Oil & Refining company has announced the appointment of Arthur A. Draeger as manager of economic and marketing research.

He will succeed Robert P. Ferguson, who transferred to the marketing coordination department of the parent Standard Oil company (N.J.).

Mr. Draeger joined the Esso division last year as assistant manager of marketing for New York state. He will move to Esso headquarters in New York City from the New York sales area headquarters at Pelham, Westchester County.

During 25 years with Humble in Texas, Mr. Draeger advanced through research positions to become head of the technical service division and head of the research and development division. Before his transfer to New York state last year, he was manager of the northeast area of the Humble division's marketing department, with offices in Dallas.

Cato Oil and Grease Announces a Number Of New Appointments

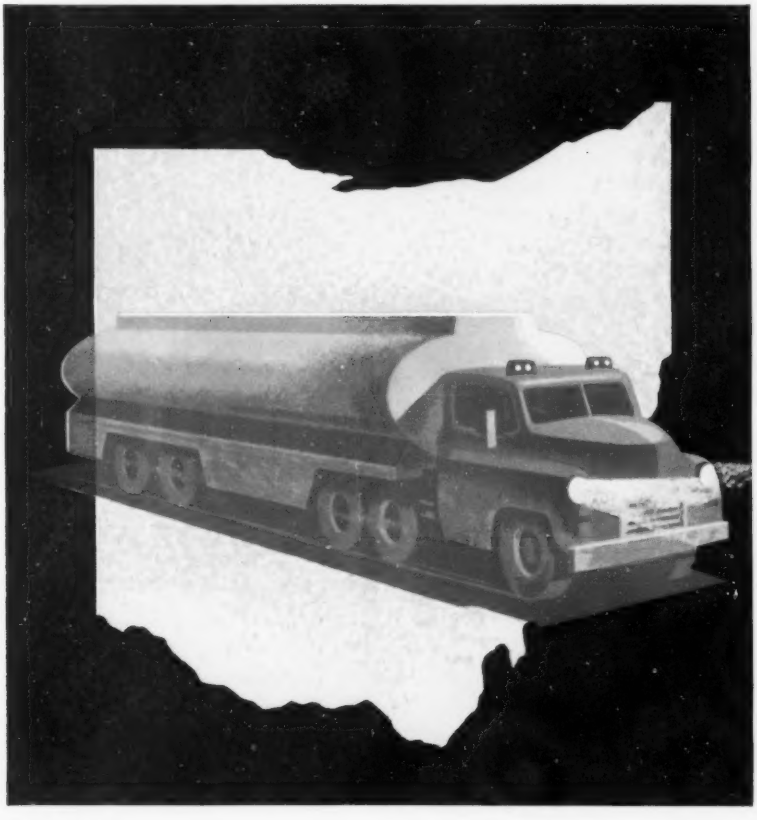
Cato Oil and Grease company, Oklahoma City, has announced a number of new appointments. Lee R. Wood is now technical sales representative for the west Texas and eastern New Mexico territory. A veteran of more than 35 years in the lubrication industry, Wood was formerly Cato plant superintendent. He joined Cato in 1931 and has served in various capacities, including head greasemaker.

James Mankin was appointed production superintendent. He was formerly in charge of the company's grease department. His new position entails direction of the oil, grease, specialty, warehouse and drum reconditioning departments of the firm. He joined Cato in 1949.

Leo Drew replaces Mankin as superintendent of the grease department. He is a thirteen-year veteran with the lubrication company.

Joe Campbell has been placed in a new position. He will act as coordinator between the production department and the sales department of the organization. Campbell was head of the drum reconditioning department before the creation of the new job. He has been with the company 30 years.

Clint McCann, formerly Campbell's assistant, is now drum reconditioning supervisor for Cato.



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Industry News

New Lubricants Report Available from OTS

A new report, "Load Support and Anti-Scuffing Properties of Lubricants," now available from the Office of Technical Services, Commerce Department, describes the design and operating characteristics of a gear and spline lubricant tester.

Also presented are the results of studies to determine the effect of lubricant flow rate, gear speed, and inert atmosphere on gear scuff loads. Lubricant load carrying ability decreased sharply in the 5,000 to 20,000 rpm range, the report states.

A slight increase in scuff load with increasing speed was noted in some cases, but the two silicone fluids showed no significant change in scuff load when tested in an inert atmosphere.

New Company to Specialize in Synthetic And Organic Greases

A new manufacturing company which will specialize in synthetic and organic greases has been formed in St. Paul, Minn. George J. Rutman is president of the organization, which will be known as General Lubricants Mfg. Co. The firm will be a new division of Sta-Vis Oil Co., with the plant and offices at 2314 Wycliff St., St. Paul.

Mr. Rutman is also president of Sta-Vis, the H. K. Stahl Co., Petroleum Packaging Corp. and Industrial Steel Container Co.

"We are living in a new missile age which has revolutionized the petroleum and precision machine business," Rutman said. "We are on the brink of a huge market for synthetic greases to fit every need."

He said the new plant has a capacity of 50 million pounds of grease a year and will serve as a model for additional units elsewhere in the United States and Canada.

R. C. Can Introduces New Foil and Fiber Container

A laminated aluminum foil and fiber can for motor oils and viscous lubricating greases was introduced by R. C. Can company at the recent American Management association's national packaging show in Chicago. The new container, result of several years of development, is expected to find wide acceptance throughout the petroleum industry, which heretofore has considered composite containers impractical for this application.

R. C. Can's experience in producing cartridges for lubricating greases provided background and technical know-how in developing the "Foil-Kan" for motor oil. Oil companies represented at the packaging show displayed much interest in the container, it was reported.

The Foil-Kan foil and fiber container is made in four layers—an aluminum liner with folded lap stem to prevent leakage or wicking, two body layers of kraft fiber, and an outer layer of printed aluminum foil which serves as the can label. Ends can be aluminum, or conventional tin plate.

Costs are said to be approximately 20% less than conventional tin plate and approximately 14% less than aluminum cans. Savings in excess of four to five per cent in transportation costs were also indicated. Further information and sample cans are available from R. C. Can Co., 9430 Page Ave., St. Louis 32, Mo.

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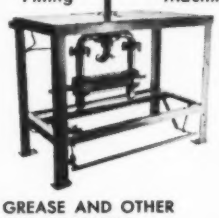

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New Water Soluble Moly Lubricant

Bemol offers a four-page, illustrated report on the newly-developed Bemol #110 Suspension, a water soluble molybdenum disulfide compound.

Covered in this report are product specifications, uses, relationship between die life and dilution ratios, and application methods. The Bemol #110 Suspension can be added directly to soluble fluids or can be diluted with water to form a drying lubricant pretreatment coating. Included are case history reports on wire drawing, heading, tube forming, deep drawing, die casting, extrusion, drilling and pretreating. The wire industry, the first major user of the product, has reported die life increases ranging from 35 per cent to well over 1,000 per cent at concentrations well below 0.5 per cent. Other advantages of the #110 Suspension are increased production rates, power consumption decreases and improved surface finishes.

The #110 Suspension is noncorrosive to all metals, plastics and rubber. It is non-flammable, nongumming, non-foaming and nontoxic. It can be used without decomposition to 750°F., and to 1,600°F. for short periods in such operations as extrusion, forging and molding. Tests have shown that the #110 Suspension resists wear at pressures up to and beyond 400,000 psi.

Copies of the report are available from Bemol, Inc., 131 State St., Boston 9, Mass.

Error Noted in 1961 SAE Handbook

A compositional error has been noted in the 1961 SAE Handbook section covering "Automotive Lubricating Greases." The error appears in the third item on page 279, "Greases Containing Solids." The editors report that, in the first draft of the paragraph, reference was made to graphite in "NOTE: (a)". In revisions, it was agreed that "NOTE: (a)" would be eliminated in favor of the text which now precedes it. Through some error "NOTE: (a)", with its reference to graphite, is included.

American Potash Names E. O. Carlton

Edward O. Carlton has been appointed sales representative for American Potash & Chemical Corp. with headquarters in Kansas City, Mo., according to John L. Anderson, Chicago district sales manager.

Carlton, a 1949 chemical engineering graduate of Purdue university, will service southern Illinois, Missouri, northern Oklahoma, eastern Kansas, Nebraska, South Dakota and southwestern Iowa.

Prior to joining American Potash, Carlton, a World War II Air Force veteran, was with Swift & Co. where he had extensive production, development and sales experience in their chemical operations.

Develops Clean Lubricating Grease

Development of the world's "cleanest lubricating grease" has been announced by Miniature Precision Bearings, Inc., Keene, N. H. Called Minapure, the grease was developed over a five-year period to meet extreme requirements for lubricating ultra-precise miniature instrument bearings. MPB is the country's largest producer of miniature ball bearings.

Minapure has been granted government approval and exceeds by a wide margin existing military specifications for grease purity. It is claimed to be 400 times cleaner than the best previously available greases meeting the highest specification. This specification permits presence of 10,000 particles of foreign matter ten microns or above per cubic centimeter. A ten micron particle is 4 ten-thousandths of an inch in size; big enough to ruin performance of a precision instrument bearing.

MPB said Minapure is available to all users of ultra-clean lubricants for complex precision assemblies such as gyroscopes and instrumentation. It is manufactured in a special processing plant at the company's Keene laboratories, under a 30-day delivery schedule.

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News About NLGI cont'd

ship subcommittee has succeeded in recommending a second fellowship subject that is acceptable to the Board of Directors. In general it will deal with the mechanism of grease lubrication and this could eventually extend the use of grease. The first phase will deal with mathematical predictions of such parameters as pressure and temperature distribution in journal bearings. Some of the pressure viscosity work previously reported in NLGI will be one of the building blocks. This committee, idle in the 1961 annual meeting program, is looking forward to a session in 1962. Here is a good opportunity to present your current fundamental research on lubricating grease. Contact Mr. Armstrong or the Steering Committee.

Another subcommittee with an eye on the 1962 meeting is the subcommittee on Gear Lubricants. The word from Philadelphia is that this subcommittee may be able to arrange a symposium on gear lubrication for that meeting. Offers of papers may be directed to Bob Smith of Houghton.

The subcommittee on Terms anticipates approval of most of the definitions in its last list of 42 terms.

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VOLUME XXIV—Bound Volume of the NLGI SPOKESMAN from April, 1960 through March, 1961. Contains 38 articles and features on every phase of the lubricating grease and fluid gear lubricants industries . . . $7.50 (NLGI member price) and $10.50 (non-member) plus postage.

NLGI GLOSSARY—A four-page booklet containing definitions of terms relating to the lubricating grease industry. Usable by marketing as well as technical people. Fifteen cents per copy (NLGI member price) and twenty-five cents (non-member).

REPRINTS — From the NLGI SPOKESMAN are available at low cost. Page forms are left standing for three months, company imprint or advertising arranged.

NLGI MOVIE — "Grease, the Magic Film," a 16-mm sound movie in color running about 25 minutes, now released. First print $300, second and subsequent orders $200 each (non-members add $100 to each price bracket).

LINCOLN MOVIE — "You—the Jury," a 16-mm sound movie in color, 18 minutes, telling the application story in the lube bay. May be reserved without charge from NLGI. A gift of Lincoln Engineering Co.

WHEEL BEARING MANUAL — "Recommended Practices for Lubricating Automotive Front Wheel Bearings." More than 170,000 copies of this booklet have been distributed throughout the world. Now in its sixth printing. Sixteen pages, with more than 40 illustrations. Twenty-five cents a copy, with quantity discounts — company imprint arranged.

BALL JOINT BOOKLET — "Recommended Practices for Lubricating Passenger Car Ball Joint Front Suspensions." The latest aid in application, created by experts in the field and designed for use in the station. Twelve pages, easy to read, with large illustrations throughout. Twenty-five cents a copy with quantity discounts—company imprint arranged.

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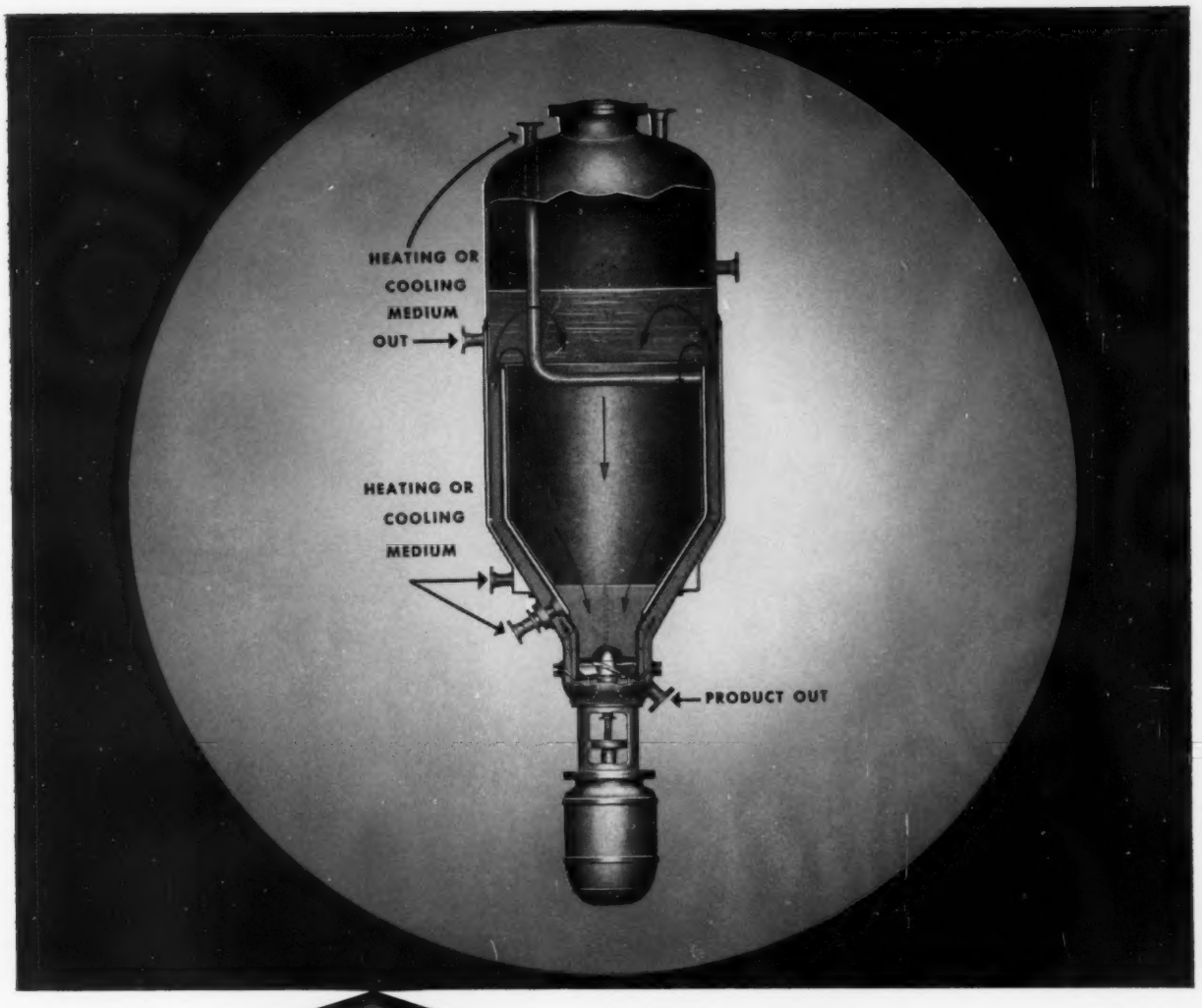

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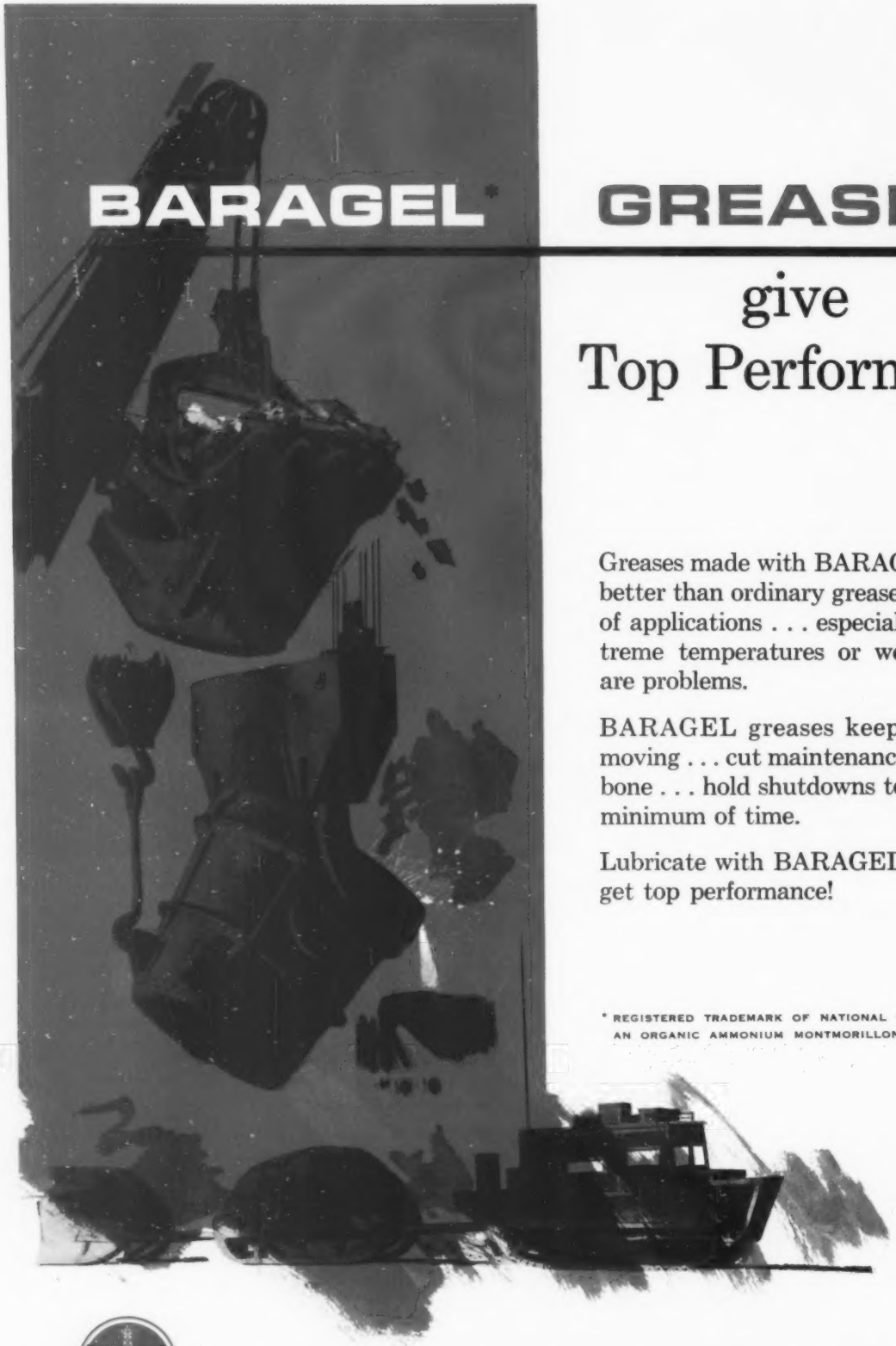

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